T-Mobile's Implementation Plan and 18 Month Status Report For Implementing the Federal Communication Commission's Fourth Report and Order on Wireless E911 Location Accuracy Requirements

February 3, 2017

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Introduction

On January 29, 2015, the Federal Communications Commission ("FCC") approved and adopted its Fourth Report and Order on Wireless E911 Location Accuracy Requirements ("4th R&O"). Among the new regulations promulgated as part of the 4th R&O were rules that for the first time extended location accuracy benchmarks to indoor 9-1-1 calls. Additionally, new location concepts were introduced, most notably the idea of Dispatchable Location. As per the FCC rules, Dispatchable Location is a "location…that consists of the street address of the calling party, plus additional information…to adequately identify the location of the calling party." Additionally, a uniform 50 meter standard was imposed on all 9-1-1 calls.

In order to meet the new requirements, T-Mobile embarked on an ambitious plan to implement the necessary technical changes and upgrades called for as a result of the 4th R&O. This included work on industry standards, establishing an Indoor 9-1-1 Location Test Bed ("Test Bed") to evaluate location technologies and assist in determining compliance, creating a system to provide Dispatchable Location and implementing other technologies, such as Observed Time Difference of Arrival ("OTDOA").

In regards to the standards initiative, T-Mobile worked primarily through the Alliance for Telecommunications Industry Solutions ("ATIS"), an organization accredited by the American National Standards Institute ("ANSI") and the North American partner for the 3rd Generation Partnership Project. Specifically, ATIS' Emergency Services Interconnection Forum ("ESIF") Emergency Services & Methodologies Subcommittee ("ESM") focused on providing guidance to the Test Bed process. ATIS's Emergency Location Task Force ("ELOC") put its efforts into developing a process by which to provide and deliver Dispatchable Location and uncompensated barometric pressure information to Public Safety Answering Points ("PSAP"). As part of the standards work on Dispatchable Location, specifications for a National Emergency Address Database ("NEAD") and National Emergency Address Manager ("NEAM") were developed.

The efforts at standing up and operating the Test Bed were significant. In order to ensure transparency and fairness, an independent company was formed to oversee the process. Much of the work was done through a combination of ATIS ESIF ESM, CTIA, equipment vendors, and other stakeholders. An indoor test methodology was developed, buildings and test points were selected, and test data was collected and certified.

Dispatchable Location efforts were equally as important. Again, an independent entity was established to oversee the process, and many of the same entities involved in the Test Bed were part of this work. The NEAD Platform, consisting of the NEAD and NEAM, was designed. Furthermore, call processes were formulated, a required Privacy and Security Plan was written, and plans were developed to begin the process of populating the NEAD with the information necessary to assist in providing Dispatchable Location.

In addition to these efforts, T-Mobile completed other projects to ensure 9-1-1 compliance. For example, T-Mobile implemented OTDOA, a network based location method associated with 4G Long Term Evolution ("LTE"), in order to complement other location technologies to provide more accurate location estimates. Upgrades were also made to T-Mobile-offered handsets and T-Mobile's Location Servers. Reporting systems were modified to comply with the new requirement to provide quarterly Live 9-1-1 Call Data Reports and to use that data to help evaluate compliance. Additionally, T-Mobile has been working with the Illinois Institute of Technology ("IIT") on Dispatchable Location proof-of-concept projects.

T-Mobile has also been working with handset manufacturers on device-based hybrid location methods, which are currently being formally evaluated in the Test Bed and have already proven to provide a significant improvement for location accuracy in challenging indoor environments.

T-Mobile is proud of the work it has accomplished to date and is focused on continued efforts aimed at improving 9-1-1 location accuracy.

Implementation Plan

This document sets forth both the status of T-Mobile's implementation work to date and the timetable for future work. T-Mobile's implementation plan consists of work already completed and the going-forward steps described in each section below. At this point, T-Mobile believes it is on track to meet the indoor accuracy compliance deadlines established in the Fourth Report and Order.

T-Mobile's Implementation Plan includes the following milestones:

- April 2016
    - Ongoing OTDOA Deployment and Optimization
    - FCC Test Bed Testing
        - Dry Run
        - Stage 1
    - NEAD RFP Process and Vendor Selection

- October 1, 2016
  - Begin collecting live call data from 6 reporting regions

- December 2016
  - OTDOA activation complete across entire network
  - Live call reporting developed

- January 2017
  - New Positioning Technology (Device Based Hybrid) tested in the FCC Test Bed Stage 1A

- February 3, 2017
  - Implementation Plan and 1st Progress Report on implementation of indoor location accuracy requirements
  - NEAD Security & Privacy Plan
  - Provide quarterly reporting on live call data from 6 reporting regions

- April 3, 2017
  - 1st Benchmark: Horizontal location requirement X/Y <=50m on 40% of 9-1-1 calls (using blended composite yield metric)

- June 3, 2017
  - Certify network deployments consistent with reporting regions for April 3, 2017 horizontal requirement

- February 3, 2018
  - Certify NEAD will be used for only 9-1-1 purposes, unless otherwise required by law

- April 3, 2018
  - 2nd Benchmark: Horizontal location requirement X/Y <=50m on 50% of 9-1-1 calls (using blended composite yield metric)

- June 3, 2018
  - Certify network deployments consistent with reporting regions for April 3, 2018 horizontal requirement

- August 3, 2018
  - 2nd Progress Report on implementation of indoor accuracy requirements.
  - Make uncompensated barometric pressure information available to PSAPs

- April 3, 2020
  - 3rd Benchmark: Horizontal location requirement X/Y <=50m on 70% of 9-1-1 calls (using blended composite yield metric)

- June 3, 2020
  - Certify network deployments consistent with reporting regions for April 3, 2020 horizontal requirement

- April 3, 2021
  - 4th Benchmark: Horizontal location requirement X/Y <=50m on 80% of 9-1-1 calls (using blended composite yield metric)

- June 3, 2021
  - Certify network deployments consistent with reporting regions for April 3, 2020 horizontal requirement and vertical requirement (Top 25 CMAs either NEAD access point entries >= 25% of CMA population or z-axis cover 80% of CMA population)

- June 3, 2023
  - Certify network deployments consistent with vertical requirement (Top 50 CMAs either NEAD access point entries >= 25% of CMA population or z-axis cover 80% of CMA population)

Standards Work Status Update

ATIS, of which T-Mobile is a member, plays a significant role in developing 9-1-1 location solutions and establishing test methodologies and other technical and operational requirements in an open forum comprised of end-to-end 9-1-1 location system stakeholders, including wireless and wireline carriers, 9-1-1 equipment vendors, and public safety entities.

Emergency Services & Methodologies Subcommittee

Much of the detailed technical development necessary to realize a practical, representative environment-based Test Bed was conducted within the ATIS ESIF ESM.

Recent ESIF ESM Highlights Relative to the FCC's 4th R&O

- Identified Test Bed geographic test areas and detailed morphology polygons for assessing wide-scale accuracy performance in environments representative of common indoor and outdoor 9-1-1 call use cases.

- Identified representative geographic regions where live 9-1-1 calls will be monitored to establish location technology yields by morphology.

- Developed the conceptual approach to detailed morphology mapping within each of the six monitoring regions to be used for location accuracy assessment.

- Developed the methodology to blend Test Bed accuracy performance indoors and outdoors with location technology yield figures across the various morphologies into a single percentage figure to gage compliance with the FCC's 4th R&O.

- Identified position method source codes for recently deployed and emerging location technologies and likely hybrid combinations of technologies.

- Developed test methodologies to assess location accuracy performance in representative indoor environments.

- Developed a comprehensive test methodology to evaluate compensated barometric pressure-based Vertical Axis (Z-Axis) location solutions.

- Developed test methodologies to evaluate crowd-sourced Wi-Fi and Bluetooth beacon-based location solutions.

- Currently developing test methodologies to evaluate and determine the veracity of dispatchable address location solutions utilizing the NEAD.

- Currently developing test methodologies to evaluate localized (small scale) location technologies with dependence on specific buildings/infrastructure within the Test Bed.

Emergency Location Task Force

ATIS formed a special working group, the Emergency Location Task Force, consisting mainly of participants from ESIF and the Wireless Technologies and

Systems Committee, to focus on developing standards for new requirements associated with the FCC's 4th R&O.

Recent ELOC Highlights Relative to the FCC's 4th R&O

- Developed specifications for the NEAD and NEAM, including requirements and assumptions.
- Conceptually defined Dispatchable Location.
- Created the architecture for the NEAD Platform that includes both the NEAD and NEAM.
- Identified the information in the NEAD necessary for carrier location servers to make a determination of the best location estimate.
- Developed specifications for the necessary interfaces, such as between carrier network and the NEAD, and the NEAM provisioning interface.
- Created architectures and call flows for both LTE and Universal Mobile Telecommunications Service ("UMTS") technologies, including control and user plane interaction.
- Developed machine-to-machine specifications to allow for batch inputs into the NEAM.
- Created use cases for Heightened Accuracy Location Information.
- Developed the method by which to provide uncompensated barometric pressure readings to PSAPs capable of receiving such information.
- Currently investigating ways to link the NEAD to externally managed Wi-Fi access points and Bluetooth beacon databases.

Test Bed Status Update

Background & Purpose of the 9-1-1 Location Technologies Test Bed

As discussed above, in 2015, the FCC adopted new rules that require the nationwide wireless providers to establish an independently administered and

transparent indoor Test Bed. The Test Bed verifies how wireless location technologies and solutions perform against the FCC's location accuracy requirements for wireless 9-1-1 calls made from various locations in representative indoor environments.

The Test Bed was established under CTIA at the direction of the national wireless carriers. CTIA established the 9-1-1 Location Technologies Test Bed, LLC ("Test Bed LLC") as an independent company to administer and operate the Test Bed consistent with the FCC's rules. The Test Bed LLC selected ATIS as the Test Bed Program Manager. In March 2016, after a competitive bidding process, the Test Bed LLC selected LCC Design Services, a Tech Mahindra Company ("LCC/TechM"), to administer and execute the Test Bed.

Test Bed Organizational Structure and Funding

The Test Bed LLC and Test Bed are modeled on the FCC's Communications, Security, Reliability & Interoperability Council ("CSRIC") CSRIC III methodology and CSRIC IV organizational structure recommendations. Testing methodologies were and still are being developed independently by ATIS ESIF ESM.

As Test Bed Program Manager, ATIS also provides guidelines on test building and test point selection and oversees implementation of the Test Bed by the Administrator, LCC/TechM. In addition, the Test Bed LLC receives advice and guidance from a Technical Advisory Committee ("Test Bed LLC TAC") and Steering Committee ("Test Bed LLC SC"), both with representatives from wireless providers and public safety.

ATIS ESIF ESM also worked with the Test Bed LLC TAC to recommend how the Test Bed should be operated to facilitate orderly testing by both wireless carriers and new location technology vendors. The test bed work was organized into different 'Stages'. Stage 1 was designated to test wireless carriers' deployed 9-1-1 location technologies for compliance assessment across the full test area. Stage 2 was designated to evaluate new and emerging location technology solutions across the full test area. Stage 3 was designated to specifically evaluate new and emerging location solutions that are localized to specific buildings/infrastructure, and therefore not able to be evaluated in the pseudo random ('blind') building test environment established for Stages 1 and 2.

In addition, ATIS ESIF ESM recommended that indoor testing occur across the 4th R&O's required four morphologies (dense urban, urban, suburban, and rural) in two specific representative test regions (Atlanta, GA and San Francisco, CA).

Through the Test Bed LLC, the national wireless providers have funded the Test Bed's operations and administration and ATIS program management. With input from the Test Bed LLC SC, the cost to support LCC/TechM's administration and execution of the test collection and analysis process is provided by each entity participating in a given test campaign. In 2016, the national wireless carriers provided the funding for Stage 1 and technology solutions vendors provided funding for the execution of Stage 2.

Indoor Location Test Methodology

ATIS ESIF ESM has and continues to develop the requisite test methodologies through a collaborative multi-stakeholder process, inclusive of wireless carriers, 9-1-1 service providers, public safety representatives, and technology solution vendors.

Adopted in June 2016, the *ATIS Standard on Test Bed and Monitoring Regions Definition and Methodology* (ATIS-0500031) provides the guidelines regarding test bed regions, morphologies, building types and construction materials ("Test Cases"). Specifically, the range of indoor operational environments in real world 9-1-1 call scenarios identified for testing include:

- The four morphologies: Dense Urban, Urban, Suburban, and Rural.
- Within each morphology there are Setting/Use types – Commercial or Residential.
- Within a Commercial or Residential use type there are building categories. For example, Single Family Home, Multi Family home, Small Office, Large Commercial, or Arena.
- Within each building category, there are different building types. For example – low rise, high rise, glass exterior, brick, and stucco.

Building Candidates and Test Point Selection

Building candidates and test points were selected by LCC/TechM, with review and approval by the Test Bed LLC's Program Manager (ATIS) and the Test Bed LLC TAC, based upon the approach initially established during the CSRIC III indoor test bed, and formalized in the Test Cases provided in ATIS-0500031.

For the various building types in each morphology, buildings with sufficient variation were identified to capture the natural variation in architecture/build and construction materials when wireless 9-1-1 calls are made indoors. A subset of twenty buildings were selected from a pool of thirty buildings available in

each of the two test regions for testing in each Test Bed stage consistent with the building types outlined in ATIS-0500031.

For each building, a number of test points were identified that reflect the anticipated range of location performance variation within the building, and generally span the different areas within the building from which an individual might initiate a wireless 9-1-1 call. The number of test points identified within a given building were determined based on the size and type of building.

The Indoor testing framework is described in ATIS-0500013 defining indoor test methodologies, and reproduced as Figure 1 below. The indoor testing framework is applicable to each of the morphologies.

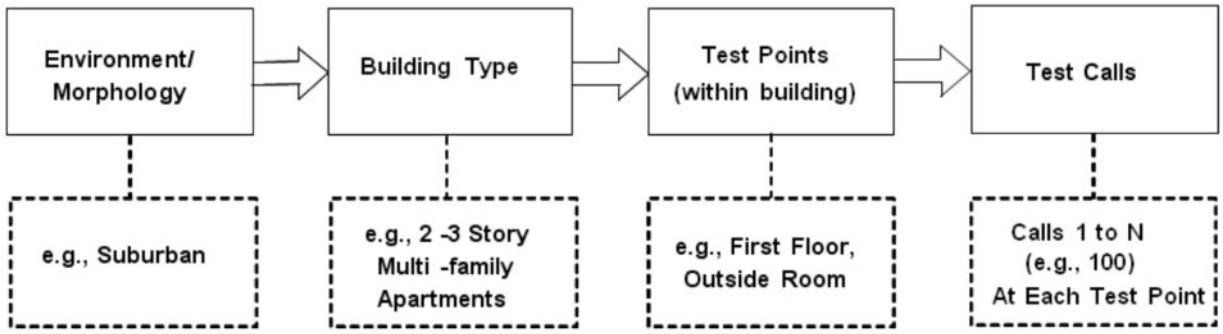

Figure 1. Indoor Testing Framework and Flow (from ATIS-0500013)

Data Collection Process

The specific buildings selected for a given test campaign and test point locations were unknown to all test participants. Ground truth for each test point location was established with the assistance of professional surveyors. A general call flow for placing test calls and collecting location data from Stage 1 is shown in Figure 2 below.

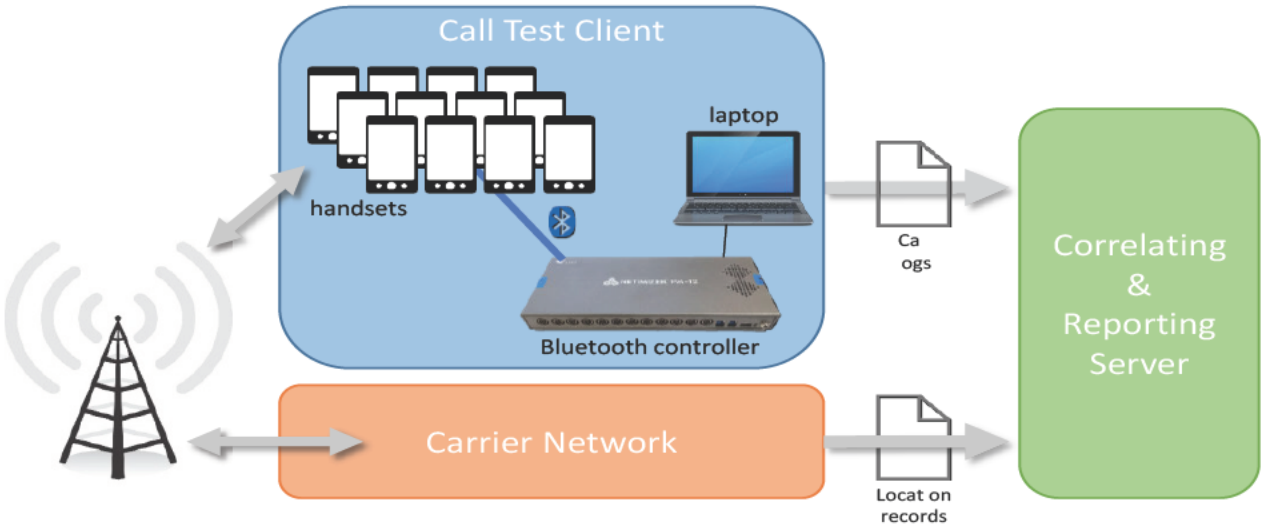

Figure 2. Stage 1 Data Collection Process Overview

The overall process consisted of testing both test regions (Atlanta, GA and San Francisco, CA) in parallel and using a standard configuration across all tested wireless handsets and carriers. This ensured that the testing process was consistent across all participants, as well as minimized any opportunity for error or variability in results. The following are the common parameters used for placing test calls at each test point during Stage 1:

- Minimum 100 stationary, successive 9-1-1 test calls per device per test participant per test point;
- Call Duration of 45 seconds;
- Call Down Time of 45 seconds to help ensure independence between successive calls;
- Handsets and controller remained powered on between test points; and
- Test Cart was rotated 90 degrees every 15 minutes during testing.

Testing was closely monitored by LCC/TechM engineers, ensuring that all testing was completed per the specifications within the Test Plan developed consistent with ATIS-0500031. If it was discovered that data collected at a particular point did not meet all requirements and a re-test was required, the tester was redeployed to the location for re-testing.

Test Bed Campaigns to Date

The Stage 1 test campaign included each of the four national wireless providers and was conducted in 3Q 2016.

Stage 2 of the Test Bed was conducted during 4Q 2016. Stage 2 involved testing emerging location technologies from four vendors, including Wi-Fi based solutions, Wi-Fi/Assisted-Global Position System ("AGPS") hybrid solutions, a device-based hybrid solution, and a hybrid metropolitan beacon/AGPS solution.

Test Bed Stage 1A – the second pass through the Test Bed for national wireless provider's compliance assessment – is currently underway, expected to complete by the end of 1Q 2017.

Future Test Bed Stages

Stage 3 of the Test Bed is currently planned for 2Q 2017.

Subsequent stages of testing will include:

- Evaluation of Dispatchable Location solutions utilizing the NEAD – tentatively scheduled for 4Q 2017.

- Evaluation of Z-Axis technologies to develop a recommended Z-Axis metric (as required by the FCC's 4th R&O) – tentatively scheduled for 1Q 2018.

Compliance Assessment

As noted in the FCC's 4th R&O, wireless carriers will blend Test Bed indoor accuracy performance data with outdoor performance data (independently developed by the wireless carrier), and apply the resulting accuracy performance metrics to live 9-1-1 call yield data aggregated across the six ATIS and FCC defined monitoring regions. Section 8 of ATIS-050031 recommends the methodology to be utilized for this blending process.

The national Wireless providers have also worked with the Test Bed LLC and the Test Bed LLC TAC to make summary Test Bed accuracy data available to non-nationwide providers to allow their own compliance assessment, as outlined in the FCC's 4th R&O.

NEAD Status Update

Background & Purpose of the NEAD LLC

The FCC's 4th R&O's new rules require wireless providers to generate either a Dispatchable Location or geodetic ("x/y") location estimate within 50 meters for wireless 9-1-1 calls with compliance benchmarks increasing over time.[1]

Dispatchable Location solutions provide the verified street address plus additional location information, as necessary, of wireless access points (e.g., Wi-Fi, Bluetooth Low Energy) that will assist in locating a caller during a wireless 9-1-1 call. By developing Dispatchable Location solutions, wireless providers are harnessing indoor wireless technologies to enhance public safety's ability to respond to wireless 9-1-1 calls from indoor locations.

In its 4th R&O, the FCC recognized the commitment of the national wireless carriers to implement a NEAD of wireless access points to support wireless providers' ability to produce a Dispatchable Location for PSAPs and first responders. At the direction of the national wireless carriers, CTIA established the National Emergency Address Database, LLC (NEAD LLC) as an independent company to administer and operate the NEAD consistent with the FCC's rules.

In October 2015, the NEAD LLC selected ATIS as the NEAD Program Manager and began a year-long competitive bidding process to select a vendor to develop and operate the NEAD. In October 2016, the NEAD LLC selected West Safety Services ("West") to design, implement, run and maintain the NEAD Platform[2] in accordance with the FCC's 9-1-1 location accuracy rules, including privacy and security requirements, and relevant technical standards.

NEAD LLC Organizational Structure

The NEAD LLC is supported by ATIS as Program Manager, West as vendor, a Technical Advisory Committee ("NEAD LLC TAC") and a Steering Committee ("NEAD LLC SC"), with the latter two being comprised of public safety and

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[1] *See Fourth Report & Order on Wireless E9-1-1 Location Accuracy Requirements*, FCC No. 15-9, PS Docket No. 07-114 (rel. Feb. 3, 2015). The FCC's rules were based on the *Roadmap to Improve 9-1-1 Location Accuracy* developed by AT&T, Sprint, T-Mobile and Verizon, the Association of Public-Safety Communications Officials (APCO) and the National Emergency Number Association (NENA), available at http://apps.fcc.gov/ecfs/document/view?id=60000986637.

[2] See section below entitled NEAD Platform Design & Technical Specifications for a description of the NEAD Platform.

wireless provider stakeholders. This organizational model is based on the FCC's CSRIC IV recommended structure for the 9-1-1 Location Technologies Test Bed.

As NEAD Program Manager, ATIS oversees and supports implementation of the NEAD Platform by West. Specifically, ATIS provides support and coordination for NEAD project management, technical specifications and standards development, and outreach to wireless access point owners and administrators. As described below, NEAD design and technical specifications are based on the standards independently developed by ATIS's ELOC through an ANSI accredited process.

The 4th R&O also recognized the joint commitment of the national wireless providers, the Association of Public Safety Communications Officials ("APCO") and the National Emergency Number Association ("NENA") to work collaboratively to establish and maintain the operational and technical functions of the NEAD Platform. Consistent with this commitment, the NEAD LLC receives advice and guidance from the aforementioned NEAD LLC TAC and NEAD LLC SC.

Through the NEAD LLC, the national wireless providers have funded the NEAD LLC's operations and administration, ATIS program management, as well as initial design, development and operation of the NEAD Platform by West. With input from the NEAD LLC SC, a cost sharing model is being developed to ensure on-going NEAD costs are allocated equitably among providers who support or utilize the NEAD for Dispatchable Location solutions.

NEAD Platform Design & Technical Specifications

Through a consensus driven, multi-stakeholder process, ATIS ELOC has and continues to develop the requisite standards upon which NEAD Platform design and technical specifications are based. ELOC membership includes wireless carriers, 9-1-1 service providers, public safety representatives, technology solutions vendors, and other 9-1-1 stakeholders.

On Nov. 3, 2016, ATIS released *Location Accuracy Improvements for Emergency Calls* (ATIS-0700028 v1.1), which is the updated standard that defines the architecture and requirements for the NEAD, as well as how information in the database is processed. In accordance with the standard, the NEAD Platform has two components: the NEAD and the NEAM. The reference model below provides an overview of the functional structure of the NEAD Platform.

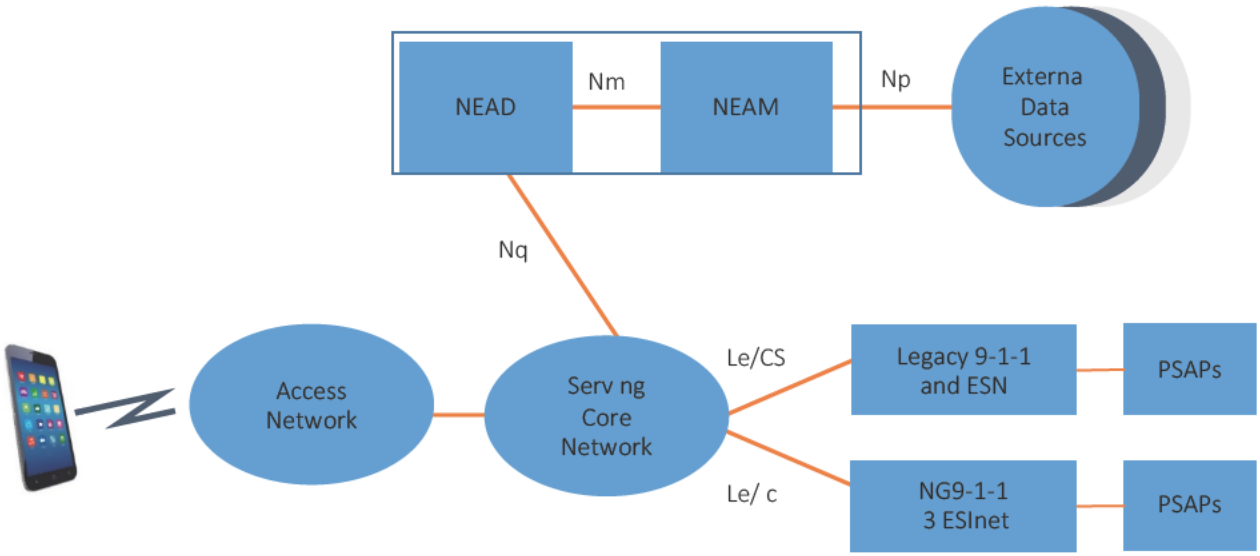

Figure 3. NEAD Platform (Consisting of NEAD and NEAM – in box)

As a component of the NEAD Platform, the NEAD is the database of verified wireless access point street addresses and additional location information, as necessary. The NEAD is being designed to respond only to authorized wireless carrier 9-1-1 call-related requests, and will only be used for emergency services purposes.

The NEAM, the management component of the NEAD Platform, is the set of systems that will receive, process, and verify information on wireless access points that are submitted for inclusion in the NEAD. Such information will generally come from three external sources: (i) service provider records of wireless access points, including Wi-Fi Media Access Control ("MAC") addresses, Bluetooth Public Device Addresses ("BT-PDA"), and associated location information, but no other customer-specific data; (ii) large enterprise system (e.g., hotels, restaurants, and retail stores) records of wireless access points, including Wi-Fi MAC address, BT-PDA, and associated location information, but no other customer-specific information; and (iii) individual consumers who will be able to voluntarily input information about their wireless access points along with information necessary for verification. A public portal (e.g., website or similar function) will be developed that will enable external sources to submit and manage wireless access points via the NEAM.

How the NEAD Call Process Works

When someone calls 9-1-1 from their wireless handset equipped with Wi-Fi and/or Bluetooth radios, the handset will scan its surrounding area for active, nearby wireless access points (i.e., any active MAC addresses of Wi-Fi access points and any BT-PDAs of Bluetooth beacons). The handset will then send the beacon address(es) it detected to its corresponding wireless carrier network.

The wireless carrier network will query the NEAD to determine whether the MAC address or BT-PDA of any of the handset-provided wireless access points is in the NEAD. If any of those access points are in the NEAD, the database will return the access point location(s) to the wireless carrier, and the carrier network will use this information to make available the best location estimate to a PSAP in response to a location request. In many cases, this should be a Dispatchable Location.

Testing Wireless Carriers' Dispatchable Location Solutions

Similar to other 9-1-1 location technologies, wireless providers will test their Dispatchable Location solutions in the 9-1-1 Location Technologies Test Bed. Testing these solutions will verify that NEAD information can be utilized to provide a Dispatchable Location consistent with the 4th R&O and parameters adopted by ATIS ELOC in ATIS-0700028.

At present, ATIS's ESIF ESM is working on the methodology to test Dispatchable Location solutions in the Test Bed. Testing Dispatchable Location solutions is dependent on the NEAD being operational for testing purposes and the readiness of the wireless networks to interact with the NEAD, which is expected to occur in the 4th quarter of 2017.

NEAD Privacy & Security Plan

Before wireless providers can make use of the NEAD Platform for their Dispatchable Location solutions, the 4th R&O requires the national wireless providers to certify that NEAD information will only be used for 9-1-1 purposes, and conditions their ability to utilize the NEAD on the FCC's approval of a NEAD-specific privacy and security plan. (47 C.F.R. 20.18(h)(3)(i)(4)(iii)).

The NEAD Privacy & Security Plan describes the operational and administrative safeguards designed into the NEAD Platform to protect personal information and maintain a reliable, resilient system. On behalf of the national wireless

providers, the NEAD LLC will submit the NEAD Privacy & Security Plan for FCC review.

Access Point Acquisition and Outreach to Wireless Access Point Owners

The FCC's Order recognizes that the likelihood of a Dispatchable Location being provided to a PSAP during a wireless 9-1-1 call is relative to the number of wireless access points within the NEAD. Over time, wireless providers' Dispatchable Location solutions will evolve into greater levels of precision as the number of wireless access points within the NEAD increases.

To this end, the 4th R&O requires the NEAD to be populated with a minimum number of wireless access points in each of the Top 50 CMAs equal to 25% of the particular CMA population by April 2023. (47 C.F.R. §20.18(i)(2)(ii)(C)-(D)).

To provide an initial base of wireless access points, the national wireless providers will submit information about their wireless access points to the NEAD in 2017. In addition, the NEAD LLC, working with ATIS's NEAD Outreach Manager, has begun developing an outreach strategy to encourage wireless access point owners and administrators, such as broadband service providers, large enterprises, and public institutions, to contribute such data to the NEAD.

The NEAD LLC expects that outreach and engagement with wireless access point owners and administrators will be a wide-ranging, multi-stakeholder, and multi-year effort. The NEAD LLC intends to engage stakeholders from industry, public safety, and enterprises to support this effort. CTIA's 9-1-1 Location Accuracy Advisory Group is also expected to provide guidance and support for the NEAD LLC's outreach and engagement efforts.

Other Efforts to Improve 9-1-1 Location Accuracy

In addition to working with industry to establish the NEAD and testing various location technologies in the Test Bed, T-Mobile has engaged in other efforts in order to meet the requirements set forth in the 4th R&O.

Observed Time Difference of Arrival

OTDOA is an LTE network based, multilateration method in which a handset measures the time difference between specific signals sent from base stations within its vicinity; the handset then reports these time differences to its affiliated wireless network. The network then uses these time differences in conjunction

with the location of the applicable base stations to calculate a location estimate of the 9-1-1 caller. OTDOA technology increases T-Mobile's ability to remain compliant on its LTE network in areas where the primary positioning method AGPS does not work, for example in some indoor locations and dense urban areas. T-Mobile has completed deployment of OTDOA technology across its LTE network and is continually optimizing the OTDOA network to increase accuracy and availability of reported positions.

T-Mobile has also deployed additional functionality on its LTE Location Server to enhance the accuracy and availability of OTDOA, such as Positioning Resource Signal muting and Inter-frequency OTDOA, as these features have been standardized and made available for implementation. T-Mobile has developed in-house tools to improve the accuracy of site level provisioned parameters, and to detect and correct provisioning errors. Increasing the accuracy of provisioned data, and calibrating out cable delays, optimizes achievable accuracy from this important new location technology.

Location Server Enhancements

T-Mobile has invested resources to upgrade its UMTS and LTE Location Servers to support GLONASS satellite functionality, in addition to AGPS. It is well known that adding a 2nd satellite constellation can significantly improve both accuracy and availability of the resulting location estimates, especially in many challenging indoor environments. Moreover, T-Mobile's systems include processes to disable network-based location measurements received through GLONASS for location estimate calculations as needed. T-Mobile has not begun to utilize this newly available functionality to improve 9-1-1 location performance, pending receive-only authorization from the FCC.

T-Mobile has also implemented upgrades to the back end connectivity of the components associated with its Location systems to enhance reliability in the network. Furthermore, T-Mobile has under development functionality necessary to provide uncompensated barometric pressure data to PSAPs from handsets that support this capability, as required by the 4th R&O.

Required NEAD Platform interfaces and functionality are slated for implementation in 2017. For further details, please see the NEAD Privacy and Security Plan.

Handset Location Technology Improvements

T-Mobile has led the wireless industry in pursuing the development and implementation of handset-based improvements to 9-1-1 location performance. The most recent development is the use of Device Based Hybrid ("DBH") location, where the handset merges satellite-based location with crowdsourced Wi-Fi positioning and makes use of additional sensors in the handset beneficial to location determination. This hybrid combination of complementary location methods provides consistent high-accuracy, high-availability performance across all four morphologies. This solution is an important complement to existing location technologies available for 9-1-1. DBH is currently being formally evaluated in the Test Bed and has already proven to provide a significant improvement for location in challenging indoor environments.

Outdoor Accuracy Data Collection

T-Mobile has collected the necessary outdoor location accuracy data for the two Test Bed test areas (San Francisco and Atlanta), through a dedicated drive test campaign. This outdoor accuracy data will be blended with the indoor accuracy data from the Test Bed, to provide the needed accuracy figures (percentage <= 50 meters) by location technology and morphology.

Quarterly Live 911 Call Reporting

T-Mobile utilized the ATIS generated morphology maps to classify and provision each cell/sector in our network within the six monitoring regions by morphology. This classification allows statistics for each live 9-1-1 call to be reported by location technology yield and morphology, in meeting the Order's requirement to file quarterly live 911 call reports.

These live call location technology yield figures will be paired with the blended indoor/outdoor accuracy results (by morphology) to compute an overall performance figure to assess compliance with the specific performance benchmarks in the Order.

Illinois Institute of Technology

T-Mobile is working with IIT's Graduate School of Applied Technologies Real Time Communications (RTC) Lab, a unique venue in which industry and academia

connect and collaborate. One of the RTC Lab's areas of focus is on NG9-1-1, and it has hosted several of NENA's Industry Collaboration Events.

Specific to this report, at the behest of T-Mobile, the IIT RTC lab has engaged in an ongoing project that provides proof of concept demonstrations of Dispatchable Location. This demonstration includes a Campus Emergency Access Database, Wi-Fi Access Points, Bluetooth beacons, and a dedicated NG9-1-1 Emergency Services Internet Protocol Network. During this time, T-Mobile has interacted with faculty and staff, providing support, insight, and direction to ensure that the work being done models how the NEAD will function in the real world. IIT has conducted several successful demonstrations of its Dispatchable Location solution, including at the 2015 NENA Critical Issues Forum in Austin, TX.

Conclusion

T-Mobile has put forth considerable effort to implement technologies and policies necessary to meet the new regulations promulgated in the FCC's 4th R&O. T-Mobile has been an active participant in the various standards work, helping to develop the requisite test methodologies for the Test Bed and the design specifications for the NEAD Platform. T-Mobile has been an active part of the Test Bed process and is working diligently with other stakeholders to successfully implement the NEAD Platform. T-Mobile also has engaged in further efforts such as implementing OTDOA across its entire LTE network and upgrading its Location Servers and handsets to improve location performance. Furthermore, T-Mobile has refined its reporting systems in order to comply with the 4th R&O's new reporting requirements and has worked with IIT to demonstrate how Dispatchable Location will work. T-Mobile is on track to meet its 9-1-1 location accuracy obligations, is proud of its efforts to date, and looks forward to further improvements in 9-1-1 location performance to benefit our customers during emergencies.